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REVIEWS

Geologic Map of Brazil. By J. C. BRANNER. Geological Society of America. "Outlines of the Geology of Brazil With Map." Vol. XXX, pp. 189-338. 1919.

Branner's Geologic Map of Brazil (Plate I) covers an area as large as that of the United States between the 49th parallel and Mexico, approximately three million square miles. It is on the scale of 1:5,000,000 or 1 inch to 80 miles. It is thus a wall map similar in scale and scope to the Geologic Map of North America of 1911.

This important contribution to our knowledge of South America centers chiefly in the geologic map, to which the accompanying text, although it comprises 150 pages, is merely an accessory. The base map was prepared by Dr. Branner, who constructed it in accordance with all available geodetic data and the personal information which he had gathered, supplemented by the maps listed in the accompanying text. The geologic coloring represents the distribution of the major stratigraphic divisions completely and in some detail for the eastern states, stands for reconnaissance in the Amazon region and along the foothills of the Andes, but is lacking over the central plateau for an area of approximately 500,000 square miles. There are also some other lacunae representing the imperfections of even general information regarding the geology. One of the most conspicuous, because it occurs in an otherwise well-known part of the country, traverses Minas Geraes and Bahia and covers the line of contact between Lower and Upper Permian, which cannot be traced with accuracy in this strip.

The geology is sketched very broadly. Thirteen divisions of the geologic column are represented, namely:

- | | |
|---------------------------------|-------------------|
| 13 Quaternary | 7 Upper Permian |
| 12 Miocene and Pliocene | 6 Lower Permian |
| 11 Eocene | 5 Carboniferous |
| 10 Cretaceous | 4 Devonian |
| 9 Igneous rocks of Mesozoic age | 3 Silurian |
| 8 Triassic | 2 Early Paleozoic |
| | 1 Archean |

It is obvious that there are large breaks in the sequence, due either to lack of knowledge or to unconformities. Both conditions exist. Geologic history is meagerly recorded in the great plateau of Brazil, which, in many respects, closely resembles the Laurentian Plateau of Canada and its marginal areas. Our knowledge of the record as far as it exists is also very incomplete.

The author says:

In view of the limitations of our knowledge, it is not possible to represent on the map more than thirteen subdivisions of the geologic column. In some localities many more subdivisions are known and, over a limited area, might have been shown, but there would be no particular object in giving all of these subdivisions on a map of this scale. The minor details, even where they are known, are necessarily omitted on account of the small scale of the map. In regions of horizontal rocks, where partings are dendritic in form and outliers are abundant, these features cannot conveniently be shown. The areas of old crystalline schists are almost everywhere traversed by dikes of eruptive rock, but these dikes are usually too small to be shown on the map of the scale of this one. The same thing is true in the southern states, where numerous dikes cut all of the rocks below the Cretaceous.

The degree of generalization in classification in the map of Brazil is similar to that of McGee's geologic map of the United States (1884), but only a small portion of the map of Brazil is based on detailed topographic and geologic surveys like those which were available to McGee. Rather might we compare Branner's map with that of the United States by Marcou (1853)¹ or by Hitchcock and Blake (1874).² Dr. Branner himself has expressed the opinion that the geology of the United States was better known when Marcou published than is that of Brazil today. Branner's map is, however, far superior to Marcou's as a work in cartography, because of its rigid adherence to known facts, although it cannot be compared with Hitchcock's from the point of view of completeness of knowledge.

Judging by these criteria it is reasonable to state that knowledge of the geology of Brazil is more than half a century behind that of the United States. To a certain extent this may be attributed to physical difficulties, tropical vegetation, soil covering, and the general absence of fossils. But a more potent cause is the lack of general interest among

¹ Jules Marcou, "Résumé explicatif d'une carte géologique des Etats Unis et des provinces anglaises de l'Amerique du Nord, etc.," *Bull. de la Soc. Géol. de France Second Series*, Vol. XII, 1854-55.

² C. H. Hitchcock and W. P. Blake, Geologic Map of the U.S. in *Statistical Atlas*, Ninth Census, 1874.

the peoples of Brazil in geology, either from the scientific or the practical point of view. There are but few trained investigators in the country, and there is great need of adequate public sentiment to support either state or national surveys. Those far-sighted Brazilians who appreciate the importance of a knowledge of the geologic history and resources of their country advance but slowly against the lack of interest of the people and the inertia of the bureaucracy.

The scientific world will share with the author of this map the hope that his contribution to the world's knowledge of Brazil may stimulate interest among the people of that country in a truly scientific, thorough survey of their great domain. Many of the enlightened nations of the world are carrying on such a survey and regard its cost as a necessary charge on the national budget, because in the long run the advantage to the nation far more than outweighs the expense. It is, however, a mistake to assume that returns from the money invested in a geological survey are either evident or immediate. The principal object is to make and publish maps and reports which shall furnish reliable information regarding the country, and thus promote its development, increase its population, and augment its sources of revenue. Brazil greatly needs a well-organized topographic and geologic survey, such as can be executed only by a trained staff, in order to inform her own people and the world regarding her resources in agriculture, water powers, and mineral wealth, and also to promote the investment of capital on the sound basis of scientific knowledge.

The text accompanying the map includes an extensive bibliography of the sources of information which the author has discovered during what we may well call an exhaustive study of the subject. The list consists almost exclusively of the names of European and North American travelers and geologists. One of the earliest is von Eschwege, who occupied an official position in Brazil and wrote on the geology of the country just a century ago. Hartt, as head of the Geological Survey in the seventies, organized important investigations and himself made contributions to our knowledge, but he was rather a zoölogist than a geologist. His successor, Derby, who held the position as head of the Geological Survey up to the time of his death in 1915, stands officially for the principal work carried out under national auspices. With these should be named Dr. Gonzaga de Campos, a Brazilian geologist who has done much to advance the exploration of his country and is still in active service. There are many distinguished names in the list of investigators cited by Branner, but there is none who has brought to the

study an equal understanding of stratigraphic and structural problems or has pursued the investigation so persistently as has Dr. Branner himself.

In his foreword the author states:

The accumulation of the data for the geologic map of Brazil was begun by me in 1874, when I first went to that country, and has been kept up as opportunities offered, down to the present time. The gathering and study of the material and the preparation of the map may therefore be said to represent the work of a considerable portion of a lifetime.

In addition to the large amount of information secured through his own personal observation the author has utilized the work of his several assistants, who have accompanied him on his expeditions to Brazil, and he has availed himself of every scrap of published or unpublished data which could stand the rigid scrutiny to which he subjected it. His resources in every direction have been unusual, but what stamps the map with authority is the character of its author, whose life-work in Brazil it epitomizes.

The geologic facts recorded in the map and accompanying text will serve three classes of students. Those who are interested in the history of Brazil as an example of the geological development of a great continental nucleus will find in the summary comprised under "Outlines of Stratigraphic Geology," pp. 202-23, a brief but comprehensive statement. Those students who may be interested in the geology of individual states or in local details will turn to the general geology described by states in alphabetical order, and to the bibliography which follows the statement regarding each state; and those who are chiefly interested in the economic resources will find valuable notes also under the separate articles regarding individual states.

Branner's text is in itself a summary. As may be seen by reference to the extensive bibliographies accompanying the descriptions of the several states, a full discussion would constitute a large volume. In order, however, to indicate the general facts of the geology in bare outline the summary may be summarized as follows:

The Brazilian complex, or basement, of the Brazilian plateau of South America is a mass of crystalline metamorphic and eruptive rocks, granites, gneisses, and schists, which closely resembles the Archean complex of the Canadian shield. They constitute the surface in the eastern mountain ranges and plateaus, forming a broad belt all along the Atlantic Coast, except in the far south. They occur both north and south of the geosyncline of the Amazon Valley, and outcrop at numerous

points in the plateau of Matto Grosso. Occurring either in these rocks or derived from them are gold, copper, platinum, tungsten, mica, marble, talc, apatite, graphite, potash-bearing rocks, precious stones, and building stones.

Distinctly younger than the Brazilian complex or Archean is a sequence of metamorphic rocks of unquestionable sedimentary origin, consisting of quartzites, schists, limestone, and the great iron-bearing formations of Minas Geraes. These strata occur imbedded in the Archean, which unconformably underlies them and by which they are in part covered in consequence of overthrusting. Their age is indeterminate, as no traces of fossils have been found, but they are assigned by Branner to the early Paleozoic.

It is evident that a period of profound diastrophism intervened between the deposition of these "early Paleozoic sediments" and the next succeeding strata, which are sandstones of Silurian (Niagara) age. To the systematic geologist it is a question of some importance whether the deformation occurred in the early Paleozoic or possibly in pre-Paleozoic time, as might be the case if the metamorphosed sediments belonged to the pre-Cambrian. It would seem that we have here a problem not unlike that of the later pre-Cambrian formations of the Lake Superior region which, by some geologists, are considered to include Cambrian rocks.

These ancient metamorphosed strata are economically of very great importance. They include the enormous iron deposits and the important occurrences of manganese. Gold-bearing veins occur in them, and the diamonds and other precious stones of Brazil are supposed to have been derived from them.

The Silurian sandstones already referred to are the oldest fossiliferous rocks known in Brazil. They are of Niagaran age and occur on the northern side of the Amazonian geosyncline, dipping gently southward. Branner expresses the opinion that it is highly probable that there are rocks of Silurian age in other parts of Brazil, but none have as yet been identified by fossils.

Strata of Devonian age occur at widely separated points in Brazil. They are found north of the Amazon, in São Paulo and Paraná in the south, and in Matto Grosso in the west. They consist of white and yellowish sandstone and black and reddish shales. In the Amazon region, although they dip at a very low angle and are not otherwise disturbed, they are cut by dikes of diabase. In Paraná and southern São Paulo the Devonian rocks seem to rest directly on the Brazilian

complex and dip gently westward beneath the Permian. They consist of conglomerates, sandstones, and shales, and the conglomerates of Paraná are supposed to be the source of the diamonds of that state.

Upper Carboniferous beds, containing marine fossils, are exposed in the state of Pará and also in Amazonas, north of the Amazon River. They are shales, sandstones, and limestones, aggregating about 600 meters in thickness, but they contain no coal. In Bahia certain quartzites, sandstones, and conglomerates which yield diamonds and carbonados are doubtfully assigned to the Carboniferous. Branner discusses in some detail the relation between these diamond-bearing strata of Bahia and the diamond-bearing quartzites of Minas, and inclines to the opinion that they are stratigraphically equivalent. The Carboniferous rocks are not now known to contain other resources of economic significance.

The pre-Permian Paleozoic strata, which have been briefly described, appear to be restricted to somewhat local occurrences and to represent a moderate degree of sedimentation. It would seem as though Paleozoic history in Brazil had been characterized by very gentle movements of uplift and depression and correspondingly scanty erosion. The Permian, on the contrary, is composed of two widespread series Lower and Upper Permian, each of very considerable thickness. A belt of Permian rocks from 100 to 500 miles wide, more or less, extends from near the Atlantic Coast east of the Amazon, southward continuously through all the intervening states, to Santa Catharina, a distance of 2,000 miles. East of it lies an even broader belt and one of equal length, consisting of the Brazilian complex and the infolded Paleozoic rocks. The latter constitutes the Atlantic Coast ranges of Brazil and the eastern part of the Brazilian plateau, while the Permian rocks form the surface of the plateau farther west. The Permian rocks were apparently deposited in a great geosyncline, which developed in the strip where they now occur along the western base of a mountain range that furnished the materials for the sandstones and shales. There is thus evidence that eastern Brazil was mountainous in Permian time as it is today, and there is a certain parallelism between the orogenic structure of eastern South America and that of the eastern United States in Permian time.

Branner summarizes the description of the Permian of Brazil, saying that the rocks "seem to be mostly sandstones and shales, slightly disturbed, but they include extensive beds of limestone—all of them cut here and there by eruptive dikes. In São Paulo, Paraná, and Santa Catharina the Lower Permian contains glacial till with striated boulders."

He discusses at some length the evidences of the age and extent of the Permian glaciation, and cites the observations of a number of geologists and travelers upon the occurrence of the strata and fossils by which they have been identified. He distinguishes the Upper and Lower Permian, both in his text and on the map, except that he has not indicated the boundary between the two where its location is not definitely known, on the headwaters of the Rio São Francisco. The Upper Permian is described as unconformable upon the Lower, but the break is marked only by a change in sedimentation.

The coal beds of Paraná, Santa Catharina, and Rio Grande do Sul are economically important, as are also the Permian bituminous shales of the southern states. The limestones will yield materials for the manufacture of Portland cement.

The pre-Mesozoic rocks, including the Permian, constitute the mountains and plateaus of all of eastern Brazil, which is thus a great geologic province whose history since the close of the Paleozoic has been that of a continental area subject to erosion. With the exception of small areas of Tertiary rocks along the Atlantic Coast and an embayment of Cretaceous and Tertiary strata in Bahia and Piauhý there are no post-Paleozoic sediments in the area.

The Mesozoic rocks occur southwest and west of the great Brazilian plateau. They comprise the red sandstones of the Trias, extensive outflows of pre-Cretaceous igneous rocks, and sandstones and limestones of Cretaceous age. The Trias is most widely represented in western São Paulo and southern Goyas. The igneous rocks, erupted through the Trias and spreading out as very extensive lava flows similar to those of the Columbia lavas, occur in Rio Grande do Sul, Santa Catharina, Paraná, and São Paulo. They occur as interbedded sheets exposed along the canyon of the Paraná, where, on account of the small scale, the coloring of the map gives an appearance of a widespread igneous mass under the Trias.

The Cretaceous is distributed in the form of remnants capping the Triassic plateaus, and extends northwest across Matto Grosso to the Andes and also north to the Amazon Valley. In the northwest and north it appears to rest directly upon the Brazilian complex, the older rocks being absent.

The Tertiary formations of Brazil are briefly described as comprising freshwater and land deposits of the territory of Acre, brackish water deposits in Amazonas, and marine deposits in Pará, Maranhão, and also in Rio Grande do Norte. Marine Tertiary occurs along various sections





of the coast, and Tertiary lake beds are found in Rio de Janeiro, São Paulo, and Minas.

Following the systematic summary of the geologic series represented in Brazil, Branner gives a fuller account of the geology of each province, and with it a bibliography of the works of travel and scientific exploration describing that state. The outline concludes with statements regarding the economic resources and mining laws of Brazil.

It was not the author's purpose to give a full discussion of the geology of Brazil. He refers, on the contrary, constantly to the original documents upon which he has drawn to supplement his own personal knowledge.

Dr. Branner has, with the aid of the Geological Society of America, made a very important and fundamental contribution to the geology of South America. The Society is to be congratulated upon the service it has thus rendered to science. The author also is to be felicitated, but he has the deeper satisfaction of having achieved the purpose of a lifetime, of having laid the foundations of the geology of Brazil firmly in an exact account of the present state of knowledge.

NOTE.—The *Outlines of the Geology of Brazil* with the geologic map is published in the usual edition for the use of the Society, in English, and in a Portuguese edition of 1,000 additional copies. There are also 500 extra copies of the map. It is regrettable that the number of copies of the text and map available to the general public is so limited.

In many paragraphs the reader will be embarrassed by the lack of any means of identifying the localities named. It was not possible to put all the names or any large part of them on the map. Neither do they all occur on maps contained in the usually available atlases. An index of place names, giving the location by latitude and longitude, would have been of great assistance.

Translations of the quotations which are given in the original languages, notably of the Portuguese, would have helped many readers.

BAILEY WILLIS

EXPLANATION OF PLATE XII

The accompanying map is a reduced photograph of the original and, in order to make it legible, numbers have been inserted on the principal areas of the different formations. The following is the list of formations distinguished:

13. *Quaternary*.—Alluvial deposits, stone reefs of the northeast coast, and the sandstones of Fernando de Noronha.

12. *Miocene or Pliocene*.—Tertiary of the upper Amazon, the coast and lake beds of Minas, São Paulo, Bahia, and Rio de Janeiro. Catinga limestones, Bahia.

11. *Eocene*.—Maria Farinha, Olinda, Pernambuco, Alagoas, Piahas, Maranhão, Natal, and the coast.

10. *Cretaceous*.—Sergipe, Bahia, Serra do Araripe, Ceará, Parahyba. Parecis beds of Matto Grosso. Baurú of São Paulo (Wealden) Maranhú Bahia. São Bento series of Santa Catharina.

9. *Igneous Rocks*.—Pre-Cretaceous igneous, alkaline rocks and their associates, including nephelene syenite, foyaite, tinguaite, phonolite, syenite, trachyte, gabbro, diabase, diabase-basalt, and the Triassic "trap" of the southern states.

8. *Triassic*.—Maracajú of southern Matto Grosso; Botucatú of São Paulo; Rio do Rasto of Santa Catharina; Santa Maria, Rio Grande do Sul with Scaphonyx.

7. *Upper Permian*.—Passa Dois series of Santa Catharina, Stereosternum and Mesosaurus beds with cherty concretions of São Paulo. Piauhy, Bahia (Aricy); Estancia beds of Sergipe, Maranhão e Goyaz (Psaronius beds), Matto Grosso.

6. *Lower Permian*.—Tubarao series of Santa Catharina; coal beds of southern states with Glossopteris flora; glacial beds, Orleans conglomerate. Serra Grande series of Piauhy and Ceará of Small. Salita Limestones, Bahia Limestones of Rio das Velhas.

5. *Carboniferous*.—Marine beds of Rio Uatuma, Frechal e Pedra do Barco in Amazonas; Itaituba, Trombetas, Maecurú and Curuá, Para; Lavras quartzites of Bahia.

4. *Devonian*.—Ereré (above), Maecurú and Curuá in Amazon valley. Ponta Grossa shales in Paraná; Chapada in Matto Grosso; Caboclo shales, Bahia.

3. *Silurian*.—Rio Trombetas, state of Pará. Tombador in Bahia Cuyabá slates, etc.

2. *Early Paleozoic*.—Itacolumite? Iron manganese and schists of Minas Geraes; quartzites of Serra de Jacobina and elsewhere in Bahia. Lisboa's Bodoquena of Matto Grosso.

1. *Archean*.—Brazilian complex: gneiss, schists, granite.

Quicksilver in 1918. By F. L. RANSOME. Mineral Resources of the United States, 1880. U.S. Geological Survey.

There were no events of conspicuous importance or unusual interest in the quicksilver industry in 1918, but Dr. Ransome's annual review of the industry for that year is noteworthy not only as an excellent concise review of the industry, but because it contains a twelve-page list